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Minnesota's Response: The Mosquito Research Program

JOHN WASHBURN and NANCY READ*

ABSTRACT — The Minnesota Mosquito Research Program (MMRP) was established in September 1984 in response to a request by Governor Perpich. The Minnesota Department of Health (MDH), as the lead agency, brought together a Working Group of distinguished North American experts to discuss the problems related to mosquito research and control. This Working Group—with advice from legislators and representatives from the community, environmental groups, and state and federal agencies—made recommendations for the development of a mosquito research and control program in Minnesota.

The Working Group divided its recommendations into two areas, research and administrative structure. An extensive *research program* in the following five subject areas was recommended: (1) the ecology, physiology, and biosystematics of mosquitoes; (2) baseline data on non-target organisms and environmental monitoring; (3) the impacts of mosquitoes on human and animal health, the economy, and the quality of life; (4) development and assessment of mosquito management strategies; and (5) local decision making and program development, based upon state leadership and standards, mosquito management training, and public education programs.

The MDH will work closely with the University of Minnesota to support a *central research facility* and personnel in the Department of Entomology as well as related research in other University departments. *Field research stations* will be established in conjunction with the University and other state agencies. A *competitive grants program*, open to public or private researchers, will be set up to support additional related research.

Problem Statement: Mosquitoes in Minnesota

Minnesota is a national leader in mosquito production. The most productive sites in Minnesota are not lakes and rivers but temporary snowmelt and rainwater pools, shallow marsh borders, and wet pastures. A conservative estimate is that at least 3% of Minnesota outside the Twin Cities metropolitan area (1.6 million acres) is potential mosquito breeding area.

Different regions of the state have different types of breeding habitats and different mosquito problems (Figure 1). In the Twin Cities metropolitan counties, *Aedes vexans* is by far the most common summertime mosquito pest. Early spring "snowpool" *Aedes* are common in the northeast forests, and *Aedes triseriatus*—the vector of LaCrosse encephalitis—is present in the southeast. *Aedes vexans* and other *Aedes* have been found in the central and western prairie and the transition forest along with *Culex tarsalis*, the vector of Western encephalitis. Although these general regions have been identified outside the Twin Cities metropolitan area, very little is known about the actual population levels or pest status of most mosquito species. For many of these mosquitoes, surprisingly little is known about even their basic biology.

Mosquitoes have important health effects in Minnesota. Mosquito-borne diseases present in the state include LaCrosse encephalitis (31 cases in the past three years) and Western encephalitis (30 cases since 1975). In addition, Jamestown Canyon virus—a virus similar to LaCrosse—is present in the state and may be a newly recognized cause of encephalitis in areas with white-tailed deer populations. The cost of medical care for a single case of LaCrosse encephalitis, which predom-

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FIGURE 1

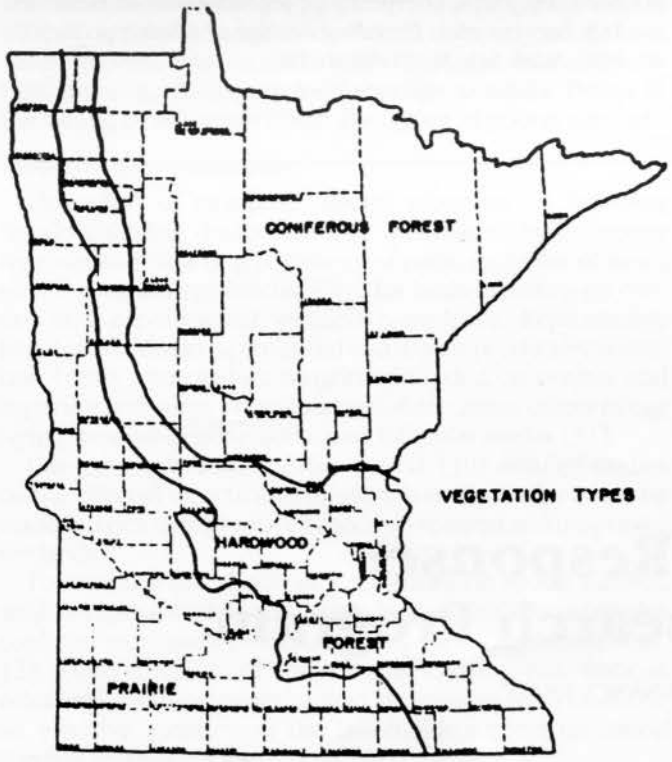

Figure 1. Three major ecological regions in Minnesota related to mosquito distribution (2).

inantly affects children, has been estimated to be as much as $20,000. Allergic reactions to mosquito bites pose an additional, though generally less severe (and probably underappreciated) hazard.

Animal health is also affected. Mosquito-borne heartworm caused debilitation and sometimes death in over 1,900 dogs in 42 counties in 1982 and appears to be increasing its range. Mosquito blood feeding and annoyance can cause considerable loss to animal agriculture, but very little information is available on which to base cost estimates. Some wildlife diseases may also be transmitted by mosquitoes.

The nuisance impact of mosquitoes should not be underestimated. Outdoor recreation and tourism are adversely affected by high mosquito annoyance levels. Millions of dollars are spent each year on repellents, bug zappers, and other personal controls. The Metropolitan Mosquito Control District (MMCD) alone spends $6 million per year for mosquito control. Tourists spend millions each year on control, and losses due to non-returning tourists are also estimated in the millions. Recreation and tourism provide an important contribution to the state's economy. More information is needed to estimate the impact of mosquitoes (using a method such as "denied time") and to define times of the year and areas of the state of greatest impact.

Besides health and nuisance impacts, mosquitoes form part of the diet of many animals, including Minnesota's waterfowl. Ducks, for example, feed on many aquatic invertebrates including mosquito larvae, but the effect of reducing mosquitoes in the duck diet has not been thoroughly explored.

Current methods for mosquito control are not economically feasible for use in a statewide program. The controlled-release (Altosid) briquettes now used by the MMCD give good larval control but cost about $100 per acre treated per season. In the metropolitan area, this comes out to $5.7 million (or approximately $2.75 per person). If this program were simply expanded to cover the millions of acres of breeding area throughout the state, the cost would be at least $160 million annually or about $90 per person living outside the metropolitan Twin Cities area.

There are many possibilities for new methods of mosquito control. Predators, parasites, bacteria, fungi, viruses, and selective chemicals have potential for providing effective, inexpensive, and environmentally safe mosquito control. However, most of the current research on these methods is being conducted in areas such as Florida, Texas, and California which have very different mosquito problems from those in Minnesota. Much of the control technology developed in these areas would not be applicable here. In order to tailor a mosquito control program that is biologically, ecologically, and economically feasible for Minnesota, extensive research and development is required.

The Minnesota Mosquito Research Program

In September 1984, the governor established the Minnesota Mosquito Research Program (MMRP). The Minnesota Department of Health (MDH), was charged with the following responsibilities:

1. Conducting research to increase the knowledge and understanding of the biologic factors and environmental conditions which favor the production of large numbers of mosquitoes in Minnesota, and
2. Making recommendations to the governor and legislature on methods that can be used to alter these populations, using environmentally sound physical and biological control programs, to improve the quality of outdoor life and the public health in future years.

The first step of the MMRP was to call together a Working Group of established experts in mosquito research, control, and related areas such as epidemiology and waterfowl ecology, selected by the Commissioner of Health. The role of the group was to study the situation in Minnesota and make recommendations for development of the program. Two external advisory committees, the Interagency Advisory Committee (IAC) and the Community/Legislative Advisory Committee (CLC), were also chosen by the commissioner. The IAC was designed to provide advice and input from state and appropriate federal agencies on matters related to (1) the environmental, scientific, and economic aspects of mosquitoes as pests and disease vectors, and (2) state and federal programs, laws and regulations. The individual members represent their respective agencies in review and comment on the recommendations prepared by the MMRP Working Group. The CLC was designed to provide input from legislatures and other interested parties in Minnesota on matters related to (1) the environmental, scientific, and economic aspects of mosquitoes as pests and disease vectors, and (2) public and legislative concerns to be addressed by the program. Members serve as liaisons with the organizations they represent.

Recommendations

The recommendations of the Working Group are broken down into two sections. The first section describes the research itself; the second section describes the administrative structure.

The charge to the Working Group was "to make recommendations on areas of mosquito research which (a) need new or additional study, (b) have been thoroughly studied, and/or (c) have potential to result in environmentally sound, cost beneficial control programs."

At this time there is very little information available on the many complex aspects of the mosquito problem in Minnesota. Thus, the recommendations given here emphasize the immediate need for more basic research to describe the problem. In the future, more specific recommendations on particular research and control programs will be made by a scientific review panel (described in the administrative section) as relevant information becomes available.

Research

Working from the concept of the three biomes described in the problem statement (prairie, coniferous forest, and hardwood forest), five subject areas were recommended for research. The first three form the basis of the problem definition, and the last two outline the response to the problem.

The Working Group agreed that, before *any* control can be considered for large-scale implementation, both a systematic study of the mosquito problems that exist throughout the state and a determination of areas where the positive impact of control would be greatest are needed.

Recommendation 1: Conduct research on the basic biology, distribution, population ecology, and biosystematics of Minnesota mosquitoes.

While much is known about the distribution of mosquitoes in the metropolitan area (from the work of MMCD), little is known about mosquitoes in the rest of the state. In his monograph *Mosquitoes of Minnesota,* (1) Dr. Ralph Barr described 47 species (there are now 50 species known to occur in the state). Barr considered about 30 of the 50 to be major or minor pests, but no quantitative work has been done to determine the pest status of many of these species.

The general life history is well known for many of these mosquito species. However, for most, the population ecology (i.e., the study of the intrinsic and extrinsic factors governing the abundance of a species) is not as well known. Study of natural mortality factors affecting mosquito numbers as well as knowledge of mosquito physiology may be helpful in devising new means of control. Studies of mosquito ecology will be done in conjunction with the collection of baseline data on non-target organisms (Recommendation 2) and may be used to develop ecological models of the habitats and species involved.

Some of the mosquito species, especially those found in the northeastern coniferous forest region, are very difficult to distinguish taxonomically, and studies of the biosystematics of these species (i.e., using all available information on the biology of a species to distinguish it from other morphologically similar species) would be needed to ensure consistency of identification in other ecological studies.

In order to develp a rational management program, more information is needed on (a) what species (in what quantities) are causing annoyance, (b) how their numbers are distributed throughout the season, (c) in which specific aquatic habitats they breed, (d) what ecological mechanisms govern their abundance, and (e) what governs their dispersal from the breeding site. Description of the fauna would most logically begin with landing rate sampling from representative sites within each biome.

Recommendation 2: Conduct research on baseline environmental status of non-target organisms, and assess ecological community changes associated with mosquito management.

Many aspects of the mosquitoes' ecological community may be affected, either positively or negatively, by the reduction of mosquito numbers. Baseline data on many non-target organisms and other aspects of the habitat are needed before community changes can be assessed. Details of the feeding and reproductive ecologies of the wildlife species involved can be used in predictive models to evaluate the outcome of candidate control methods. Experimental plots, either natural or man-made, may be used for these studies.

Recommendation 3: Determine the impact of mosquitoes on health (human and animal), the economy (tourism, livestock), and the quality of life in Minnesota.

The impact of mosquitoes breaks down into three main areas: health, the economy, and the quality of life.

Health. Two human diseases are caused by mosquito-borne viruses—Western encephalitis and LaCrosse encephalitis. There is new evidence to suggest that Jamestown Canyon virus and perhaps other mosquito-borne human diseases may be present but unrecognized in the state. Animal diseases carried by mosquitoes include Western encephalitis in horses and birds and heartworm (canine filariasis) in dogs. Diseases of wildlife may also be carried by mosquitoes.

Epidemiologic data are needed to quantify societal costs of these diseases and to judge whether control of the vector mosquitoes merits special attention. If so, the distribution and ecology of the disease agents and their vectors will require study in order to develop control measures for Minnesota populations.

Economy. The economy of Minnesota may be affected by mosquitoes in many ways. The suspected loss of tourism is one major area for research. Tourism respresents a significant portion of the economy, particularly in the north-central and northeastern regions of the state.

Another area for economic research is the effect of mosquitoes on livestock production. Mosquitoes have been collected from dairy cattle in enormous numbers, and, based on studies elsewhere, it seems likely that the production of milk, beef, pork, and sheep by Minnesota farmers is less efficient than if mosquitoes were controlled. Given the economic importance of animal agriculture (approximately 25% of the state's economy), this could become a substantial source of support for organized mosquito management.

Quality of Life. For many people, mosquitoes significantly detract from the quality of life in Minnesota. Residents as well as tourists often find that mosquitoes shorten their personal outdoor recreation time and temper their enthusiasm for participation in many public recreational activities. More information on the distribution of people affected is needed to decide where and when the perceived mosquito problem occurs and what the benefits of different levels of control might be. The "denied time" approach, using surveys to estimate the loss of outdoor recreational activity due to mosquito annoyance, was reaffirmed as a viable means of measuring the mosquito problem in human and, in some cases (such as tourism, gardening, or recreation), economic terms.

Recommendation 4: Develop appropriate mosquito management strategies using effective, practical, biologically compatible methods.

Many strategies for dealing with mosquito problems are currently available. These range from doing nothing or using personal repellants to large-scale projects such as those in Florida or California. Many of these strategies will not be biologically effective or financially feasible for Minnesota. Strategies need to be developed that are effective and practical in this setting, as well as biologically compatible with the other portions of the ecosystem. It is possible that no adequate strategy currently exists, and it may be necessary to develop new technology for mosquito control, be it biological, chemical, or physical control; improved repellents and public education; or something not yet imagined. For some of the more well-known species, research on management strategies can begin right away. However, much of this research depends on the results of the problem definition steps outlined in Recommendations 1, 2, and 3.

Recommendation 5: Evaluate the costs and benefits of development of local or regional management programs.

Once the problem has been well-defined and strategies for mosquito managment have been proposed, programs for use at the local or regional level can be developed. These programs could include demonstration areas and would involve administrative and training support from the state level. The choice to implement a mosquito control program would be made by each local government level depending on the costs and benefits of such a program. However, any local program would be required to abide by state guidelines developed in conjunction with the Minnesota departments of Natural Resources and Agriculture. Research collected in the development of the programs would be used to prepare Environmental Impact Statements as necessary.

Administrative Structure

Recommendation 1:

The MDH will administer all MMRP research funding. Most of the research will be done on a contract or grant basis, and the MDH will ensure coordination and integrity of effort toward accomplishing the primary objectives of the MMRP.

The proposed administrative structure for MMRP is outlined in Figure 2. The executive director of MMRP (a member of the MDH administrative staff) will serve as the overall Project Officer for MMRP, will have final administrative authority within the MMRP for program direction and administration of allocated funds, and will be responsible for reporting to the Commissioner of Health and the Minnesota Governor/Legislature regarding the status of current projects and the approval and funding of proposed MMRP projects. The executive director of MMRP will execute authority under advisement from the advisory committees and the Scientific Review Panel associated with MMRP.

Recommendation 2:

The MDH will work closely with the University of Minnesota to support a research entomologist position, a central research facility at the Department of Entomology, research by other University departments such as the Department of Fisheries and Wildlife, and field stations in major ecological regions of the state.

The research entomologist will provide the scientific leadership and expertise needed to oversee and execute most of the research of MMRP. Funds for this position should be via a long-term (at least ten year) commitment between the University of Minnesota and the MDH in order to support the type of long-range research planning and stability that is needed to ensure the success of the MMRP.

The MDH will work closely with the research entomologist to establish a central laboratory for research focused on areas of basic biology, physiology, life history, pathology, genetics, and bioassays of management tools, and to develop and assist field research and provide training for field research staff. This central laboratory will be supported by the facilities and staff at the University.

Research by the Department of Fisheries and Wildlife and by other University departments in such areas as ecology and economics will be coordinated by the research entomologist.

Field research stations should be established in each of the three major biomes in Minnesota with largely different mosquito problems (the prairie area, the coniferous forest/granitic area of the northeast, and the hardwood forest area of the southeast).

The field research undertaken in each of these stations will involve such activities as surveys of species distribution and ecology, larval studies, assessments of other invertebrate ecology, and assessments of fish and wildlife populations.

Recommendation 3:

A competitive grants program will be used to support research in subject areas not covered by the University of Minnesota program. This program will be open to all public and private agencies and individuals interested in doing research appropriate for the MMRP.

The competitive grants (contracts) program proposed is intended to provide a research fund to:

a) undertake supplemental research studies on basic mosquito biology, physiology, and ecology beyond that conducted through the proposed MDH/University of Minnesota research program;
b) undertake research into the impact of mosquitoes on human health (i.e., vector-borne diseases) and animal health (including agricultural and wildlife impacts);
c) undertake studies of other economic factors including tourism and "quality of life" impacts;
d) develop new, effective, practical, biologically compatible control methods;
e) conduct additional environmental monitoring and impact studies; and
f) undertake demonstration, training, and education programs for development of local and regional mosquito management programs.

The program will be competitive, based upon research proposals specific to Minnesota submitted in response to a request for proposals (RFP) published by MDH. The proposals will be initially reviewed by a scientific review panel of appropriate experts, and then finalists will be presented for review and comment to the advisory committees and the public. The research projects must address one or more of the six areas noted above and can be basic or applied. The research will be done in Minnesota or will be immediately applicable to Minnesota problems.

The proposals will address a particular problem, describing it and discussing proposed research. Each proposal must:

- review the existing literature pertinent to the research problem;
- have a testable hypothesis, a clear experimental design, and a description of all methods; and

FIGURE 2 -- ADMINISTRATIVE STRUCTURE

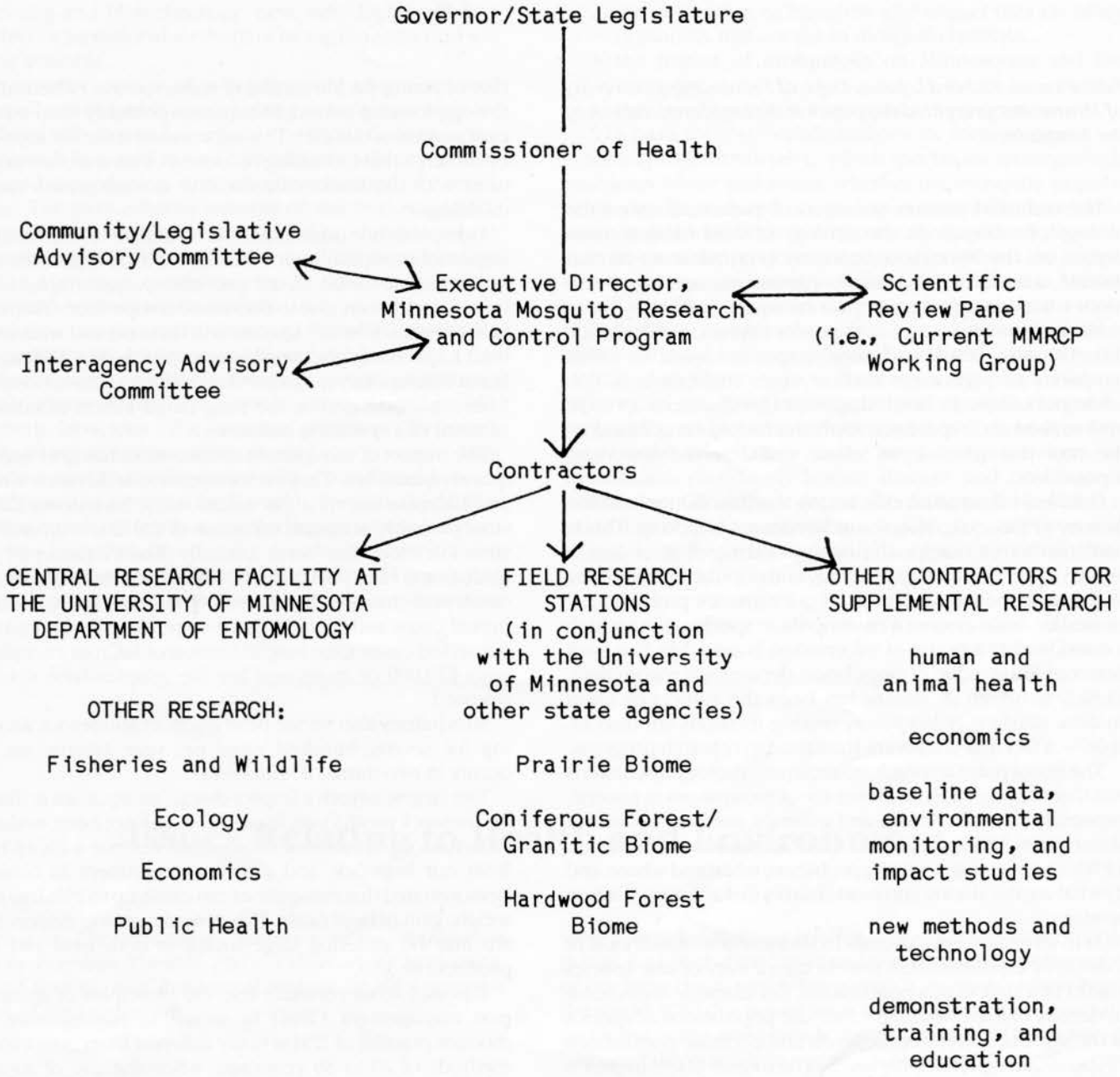

Figure 2. Proposed administrative structure for the Minnesota Mosquito Research and Control Program.

discuss the significance of the research and how results will be analyzed and disseminated.

Results of research and requests for renewal will be presented at an annual meeting to members of the scientific review panel, the advisory committees, and the public.

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